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<p>(21) International Application Number: <b>PCT/GB97/00893</b></p> <p>(22) International Filing Date: <b>27 March 1997 (27.03.97)</b></p> <p>(30) Priority Data: 9606438.1                    27 March 1996 (27.03.96)                    GB</p> <p>(71) Applicant (<i>for all designated States except US</i>): R.A. JENTON &amp; CO. LIMITED [GB/GB]; Grove House, 25 Upper Mulgrave Road, Cheam, Surrey SM2 7BE (GB).</p> <p>(72) Inventors; and (75) Inventors/Applicants (<i>for US only</i>): LITTLE, Richard, Anthony, Rudd [GB/GB]; The Old School House, 103 Waterloo Road, Freemantle, Southampton SO15 3BS (GB). BRIGGS, David [GB/GB]; Manor Farm House, Wall Lane, Silchester, Reading, Berkshire RG7 2HL (GB).</p> <p>(74) Agent: MACKENZIE, Andrew, Bryan; Withers &amp; Rogers, 4 Dyer's Buildings, Holborn, London EC1N 9JT (GB).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	
<p>(54) Title: <b>STERILISATION APPARATUS</b></p> <p>(57) Abstract</p> <p>A steriliser comprising an openable enclosure (2, 4) for surrounding one or more articles (8A, 8B) to be sterilised, the enclosure being arranged to attenuate microwave radiation such that in use, when the enclosure is irradiated with microwave energy, the microwave field energy throughout the interior of the enclosure is significantly less than that outside the enclosure, and the enclosure including a gas tight cavity (2C, 4C) containing a gaseous charge, the charge being chosen from the group of materials which emit ultraviolet radiation when irradiated with microwave radiation.</p>			

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## STERILISATION APPARATUS

The present invention relates to sterilisation apparatus.

- 5      It is well known that ultraviolet radiation has sterilisation properties. Typically arc lamps are used to produce radiation of an appropriate wavelength. These lamps must be connected to special power supplies and the apparatus is therefore somewhat cumbersome in use. Furthermore, the lamps have a limited life and suffer from shadowing problems caused by their connecting cables and internal electrodes. In the sterilisation field, shadowing can
- 10     result in parts of an article receiving an insufficient cumulative level of radiation to achieve effective sterilisation.

It has recently been appreciated that an ultraviolet bulb which is energised by microwave radiation may provide a solution to at least some of the problems associated with arc lamps.

- 15     US Patent No. 5166528 describes much of the research performed to date. This patent describes a nonconductive housing which supports one or more microwave energisable ultraviolet bulbs and which is adapted to be placed within the microwave cavity of a conventional microwave oven. An article to be sterilised is placed within the cavity either
- 20     within or adjacent the housing. In all the described embodiments, the article to be sterilised is exposed to microwave radiation. The patent acknowledges that heating of the article by the microwaves occurs but comments that this is limited because sterilisation only takes 30 to 40 seconds, for example. However, in practice, the applicant has found this to be a

significant problem, firstly because any heating of the article may be unacceptable as is the case with some contact lenses, for example, where heating causes distortion of the lens. Secondly, the length of sterilisation needed may be more than 40 seconds, and thirdly, heating of the article is not the only consideration; it is not possible, for example, to sterilise 5 a conductive article using the arrangements described in the patent. Thus, the practical applications of the teaching of US 5166528 are limited.

It is an object of the present invention to improve on the teaching of US 5166528 and in particular, to solve the problem of sterilisation of microwave sensitive articles using at least 10 one microwave energised ultraviolet bulb.

Accordingly, in a first aspect thereof, the invention provides a steriliser comprising an openable enclosure for surrounding one or more articles to be sterilised, the enclosure being arranged to attenuate microwave radiation such that in use, when the enclosure is irradiated 15 with microwave energy, the microwave field energy throughout the interior of the enclosure is significantly less than that outside the enclosure, and the enclosure including a gas tight cavity containing a gaseous charge, the charge being chosen from the group of materials which emit ultraviolet radiation when irradiated with microwave radiation.

20 Typically the gaseous charge is of mercury or a metal halide and the enclosure is substantially constructed of an ultraviolet transmissive material such as quartz which is sufficiently heat resistant, microwave transparent and ultraviolet transparent for the purposes of the present invention. By arranging for the enclosure to attenuate the microwave

radiation whilst still allowing ultraviolet radiation to penetrate, the disadvantages of the prior art are avoided.

The attenuation may be effected using only the gaseous charge which substantially  
5 transforms the incident microwave energy from the microwave to the ultraviolet spectrum by absorbing most of the microwave wavelength and retransmitting the energy in the ultraviolet spectrum. This results in an effective attenuation of microwave energy incident on the article in the enclosure. Alternatively, attenuators such as water (which convert the energy to heat) or electrically conductive elements (arranged to adjust the microwave field  
10 in accordance with conventional field theory) may be used. The object of the attenuation is to maximise exposure of the article to ultraviolet radiation at germicidal wavelengths (typically around 260 nm) whilst reducing the microwave energy field to a level insufficient to damage the article or in the case of conductive articles, insufficient to allow arcing and consequent damage to the microwave source.

15

The preferred embodiment uses only the gaseous charge to attenuate the energy level of the microwave radiation within the enclosure since this results in the most efficient use of the microwave energy (since the energy is largely converted to ultraviolet radiation rather than heat).

20

According to a second aspect of the invention, a method of sterilising an article comprises placing one or more of the articles into an enclosure, the enclosure including a gas tight cavity containing a gaseous charge, the charge being chosen from the group of materials

which emit ultraviolet radiation when irradiated with microwave radiation, and irradiating the enclosure with microwave radiation, the enclosure being arranged such that the energy level of microwave radiation inside the enclosure is less than that outside and is insufficient significantly to damage the article and whereby the article is sterilised by irradiation with 5 ultraviolet radiation.

The invention will now be described by way of example with reference to the drawings in which:

- 10 Figure A is cross-section of a steriliser in accordance with the invention, adapted for sterilisation of contact lenses;

Figure B is a cross-section of an alternative embodiment of Figure A;

- 15 Figure C is a cross-section of an alternative embodiment of Figure A;

Figure D is a cross-section of an alternative embodiment of Figure A; and

Figure E is an alternative lid for use with the embodiment of Figure D.

20

With reference to Figure A, the steriliser comprises an enclosure having a base 2 and a lid 4. In plan view, the enclosure is generally circular. The base 2 has two cradles 6A, 6B each for holding a respective contact lens 8A, 8B. The cradles 6 are arranged securely to hold the

lenses to prevent them becoming lost and may also be arranged to hold a quantity of fluid such as contact lens soaking solution or saline solution to prevent dehydration of the lenses during sterilisation. The base 2 and lid 4 are hollow to form respective cavities 2C, 4C for holding a gaseous charge which is operable to emit ultraviolet radiation when irradiated with 5 microwave radiation. Typically the charge will be a mercury charge and the lid 4 and base 2 will be constructed from quartz.

- In use, the enclosure is placed in a microwave cavity such as a resonant multimode cavity forming part of a conventional microwave oven. Microwave energy is coupled to the cavity 10 in a conventional manner and the substantially even field produced in the cavity causes even irradiation of the outer surface of the enclosure. At least some of the microwave energy is converted to UV energy by the enclosure and the UV energy impinges on an article placed within the enclosure (in this case, a pair of contact lenses).
- 15 As a result of the attenuating effect of the gas charge on microwave radiation, the area designated x in the Figure is substantially free of microwave radiation and thus the lenses 8A, 8B are irradiated substantially only by ultraviolet radiation (and are therefore not 'cooked' by the microwave energy). In a typical arrangement, attenuations of 25dB of microwave energy are attainable. Whether this is 'significant' attenuation depends on 20 whether it is sufficient to avoid damage to the article (or the microwave source if the article is electrically conductive) given the duration and intensity of the microwave radiation in the interior of the enclosure during sterilisation.

The enclosure of Figure A has external dimensions of approximately 110mm x 150mm and internal dimensions of approximately 80mm x 120mm. The gas pressure is low (approximately 1 torr or 1mmHg) and the charge is of mercury and argon. Higher gas pressures produce greater intensities of UV radiation but heat is also produced in greater quantities which in some applications, may be undesirable.

It will be appreciated that the above described arrangement and those described below may be used for the ultraviolet irradiation of microwave sensitive articles other than contact lenses.

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With reference to Figure B, an alternative lid configuration is shown in which the central portion of the lid projects downwardly into the base 2. This is an easier shape to manufacture than that of Figure A.

15 With reference to Figure C, the enclosure comprises a lid having a shape similar to that of the base of Figure A but dimensioned to be placeable concentrically within the base 2. The gap between the sides of the lid 4 and base 2 is dimensioned to have a microwave choke effect in accordance with conventional field theory. This gap will therefore be a function of the microwave wavelength and typically will be a multiple of  $\lambda/4$  where  $\lambda$  is the  
20 wavelength of the microwave radiation.

It will generally be desirable to attenuate the microwave radiation using only the gaseous charge since this results in an efficient conversion of the microwave energy into ultraviolet

energy. It may however be necessary to shield certain parts of the articles to be sterilised from ultraviolet radiation or for ease of construction of the enclosure, not to allow the cavities 2C, 4C to entirely surround the enclosure. In this case, other microwave attenuators may be used as shown for example, in Figures D and E.

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In Figure D, a conductive (preferably metallic) lid is used which is encased in PTFE or some other non-conductive material or polymer. This arrangement allows the electromagnetic shielding effect of the conductor to operate without the possibility of arcing to the conductive sides of the microwave cavity in which the steriliser is placed. This embodiment 10 also includes an internal water jacket (which may be used with any of the other embodiments) formed by constructing an inner skin 10 inside the inner surface of the base 2. A water-tight cavity is formed between the inner skin and inner surface into which water may be introduced to form the water jacket. The purpose of the jacket is further to attenuate the microwave energy as it passes through the enclosure walls. Water is convenient but not 15 essential. Other materials which are largely UV transparent could instead be used for the jacket.

Figure E shows an alternative lid which does not include a cavity 4C for a gaseous charge, in which the lid is open at the top allowing it to be filled with water. As discussed above, 20 the water attenuates the microwave energy by converting it to heat energy.

The microwave radiation may also be attenuated using a conductive, reticular material such as a wire mesh, the pitch of reticulation being chosen in relation to the wavelength of the

microwave radiation as a compromise between minimising the attenuation of the ultraviolet radiation and maximising that of the microwave radiation.

- It should be appreciated that the term 'sterilisation' is used loosely in the sense that the wavelength, intensity and duration of UV irradiation may be adjusted either empirically or using known methods in order to achieve a desired degree of bacterial destruction on the surface of the article or articles in the enclosure. It will also be appreciated that the described apparatus could be used for nonsterilisation applications such as resin and/or ink curing.

CLAIMS

1. A steriliser comprising an openable enclosure for surrounding one or more articles to be sterilised, the enclosure being arranged to attenuate microwave radiation such that in use, when the enclosure is irradiated with microwave energy, the microwave field energy throughout the interior of the enclosure is significantly less than that outside the enclosure, and the enclosure including at least one gas tight cavity containing a gaseous charge, the charge being chosen from the group of materials which emit ultraviolet radiation when irradiated with microwave radiation.
- 10 2. A steriliser according to claim 1, wherein the gas-tight cavity is integral with and defined by at least a part of the enclosure wall.
3. A steriliser according to claim 1 or claim 2, adapted for the sterilisation of one or  
15 more contact lenses.
4. A steriliser according to any preceding claim, wherein the gaseous charge is of mercury or a metal halide.
- 20 5. A steriliser according to claim 4, wherein the gaseous charge further includes a noble gas such as neon or argon and/or helium.

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6. A steriliser according to any preceding claim, wherein the pressure of the gaseous charge is less than 1 torr at a temperature of 25°C.

5 7. A steriliser according to any preceding claim wherein the enclosure is constructed substantially of a UV transmissive material, such as quartz.

8. A microwave source coupled to a resonant multimode microwave cavity, the cavity containing at least one enclosure according to any preceding claim.

10

9. A method of sterilising an article comprising placing one or more of the articles into an enclosure, the enclosure including a gas tight cavity containing a gaseous charge, the charge being chosen from the group of materials which emit ultraviolet radiation when irradiated with microwave radiation, and irradiating the enclosure with microwave radiation, the enclosure being arranged such that the energy level of microwave radiation inside the enclosure is less than that outside and is insufficient significantly to damage the article and whereby the article is sterilised by irradiation with ultraviolet radiation.

15 20 10. A steriliser constructed and arranged as herein described with reference to the drawings.

1 / 2

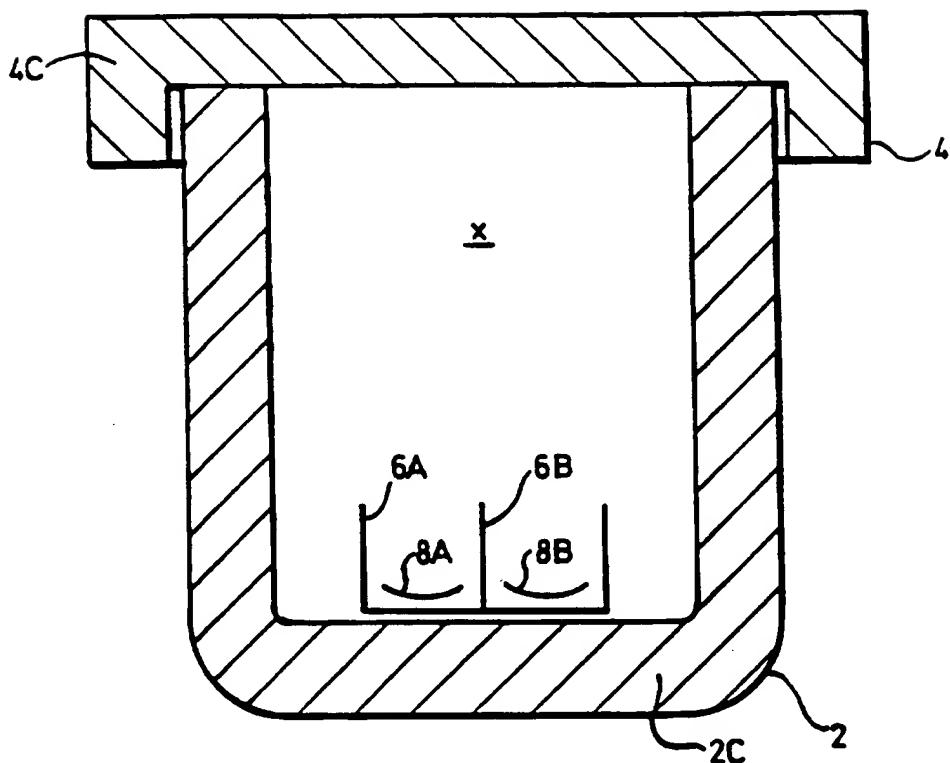


Fig.A.

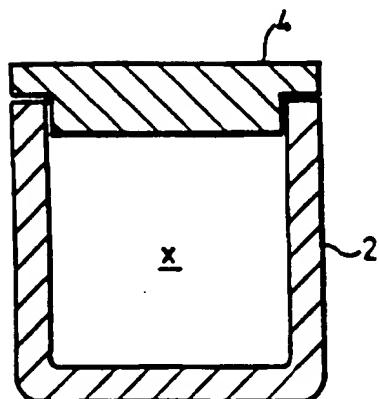


FIG.B.

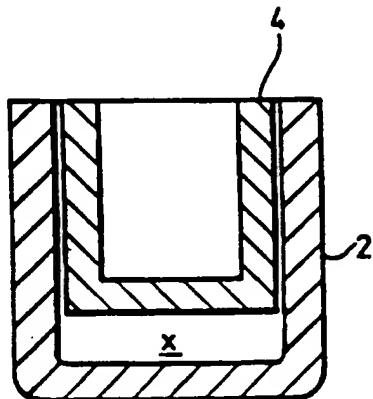


FIG.C.

2 / 2

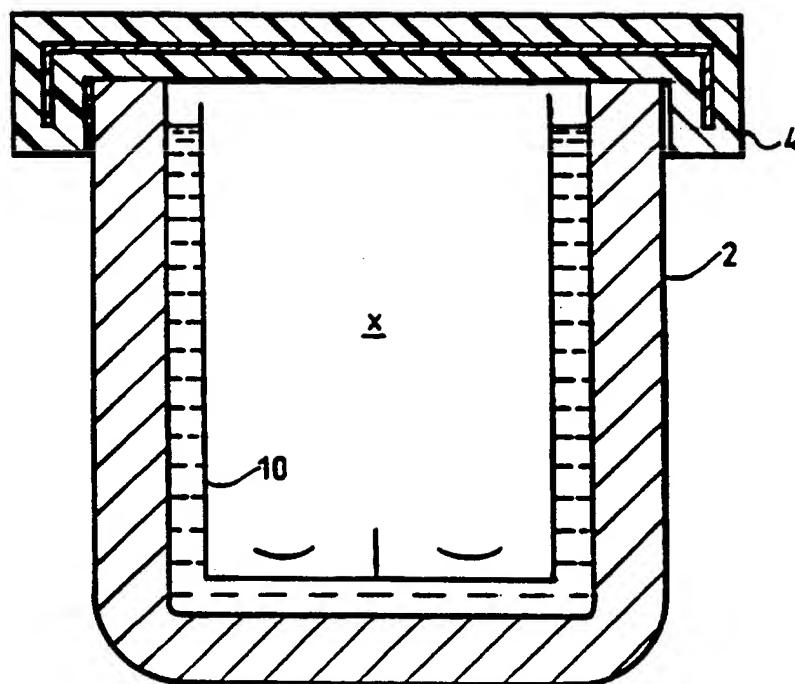


Fig. D.

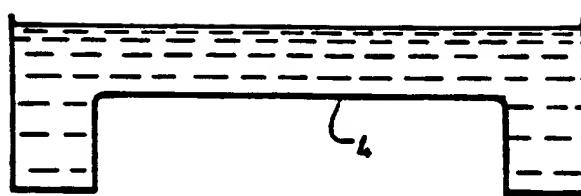


Fig. E.

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 97/00893

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 A61L2/10 A61L2/12

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,Y	WO 96 09842 A (BODY SHOP INTERNATIONAL PLC ;BAILEY WILLIAM (GB); LITTLE RICHARD () 4 April 1996 see claims	1-10
P,Y	WO 96 40298 A (SQUARED HOLDING INC R) 19 December 1996 see claims; figures	1-10
A	WO 89 09068 A (HIRSCH PAUL) 5 October 1989 see claims	1-10
A	US 5 166 528 A (LE VAY THURSTON C) 24 November 1992 cited in the application see the whole document	1-10

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of mailing of the international search report

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No

PCT/GB 97/00893

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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